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Benchmarking a Pronghorn Model of the Natural Convection Shutdown Heat Removal Test Facility Against STAR-CCM+ (Poster)

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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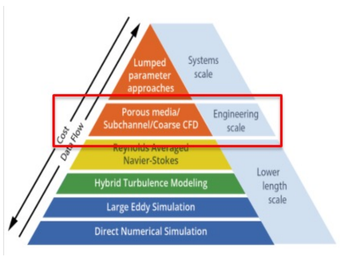
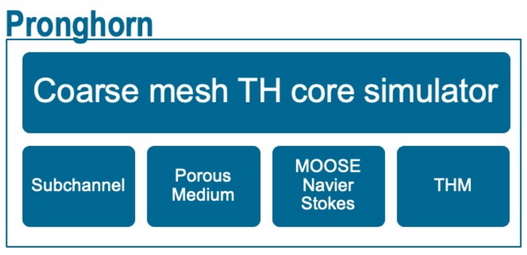
Summary

- Verification of Pronghorn's Net Radiation Transfer via Code-to-Code comparison with STAR-CCM+.
- Comparison based on Natural Convection Shutdown Heat-Removal Test Facility (NSTF).
- Near-perfect agreement if conjugate heat transfer inside the riser channels is replaced by fixed temperature.
- Difference of up to 5K if conjugate heat transfer is modeled (correlation vs. full CFD).

Pronghorn

- Pronghorn: coarse-mesh, multi-dimensional, thermal-hydraulics
- Application: PBRs, FHRs, MSRs, where transient multi-D thermal-hydraulics is important

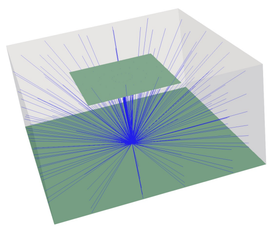




Net radiation transfer method

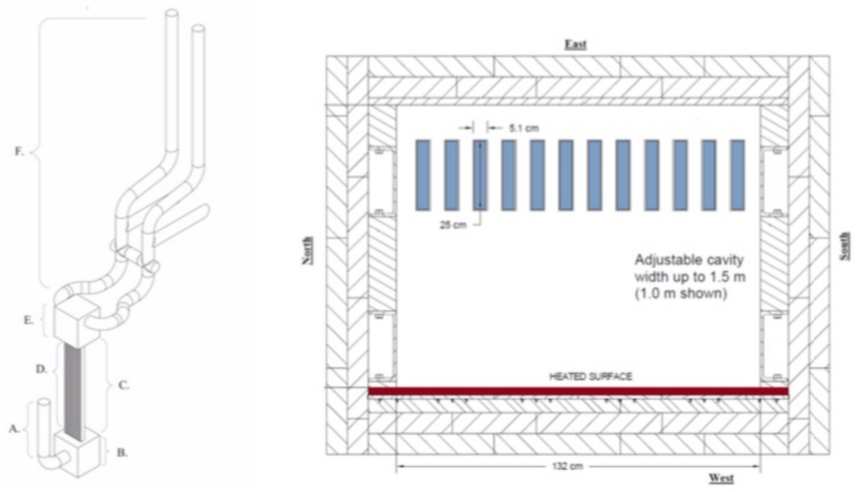
- Standard "view factor" method
- View factors are computed ray tracing module
- Important in RCCS, upper/lower plenum in HTGRs

Ray gracing for computing view factors with obstructions



NSTF Description (Air cooled)

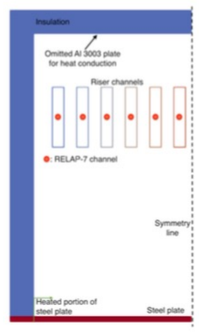
- ½ scale model of RCCS planned for GA-MHTGR
- Cavity with heated plate and 12 risers
- Inlet/Outlet piping away from the cavity is essentially a chimney sucking in air at the bottom, discharging on the top

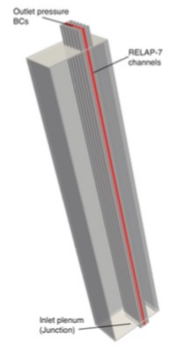


Model Parameters

- Forced circulation transient R022 (0.605 kg/s)
- Heat conduction + RELAP-7 channels + net radiation in the cavity (system level TH)
- Model A: conjugate heat transfer inside the channels
- Model B: with Dirichlet temperature boundary inside the channels

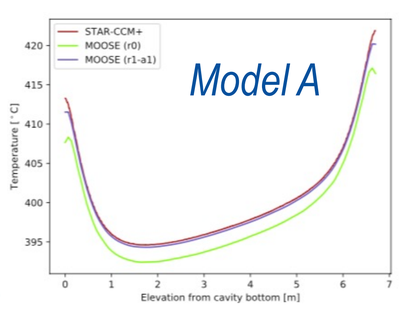
Model name	Elem count	Radiation patch count	Angular discretization
r0	348k	80/100/100	512
r1	2,786k	80/400/200	512
R1-a1	2,786k	150/800/400	960

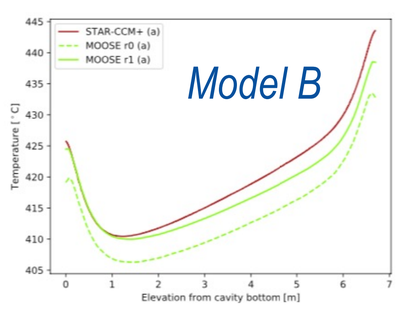


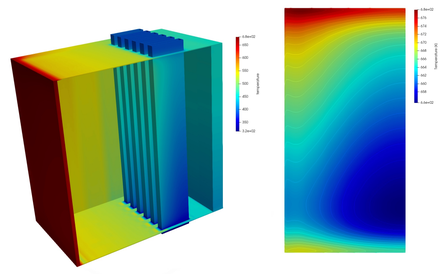


Results

- Comparison of temperature lineout on heated plate @x=0.508 m vs. STAR-CCM+
- Excellent agreement for Model A
- Up to 5 K difference for Model B caused by difference in TH model (RELAP-7 vs. CFD)







Conclusions

- Pronghorn & STAR-CCM+ agree perfectly without conjugate heat transfer
- Difference of up to 5K at the heated plate for cases with conjugate heat transfer
- Difference can be attributed to modeling TH
- Encouraging results indicating correctness of Pronghorn's net radiation transfer method

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